ASYMMETRIC MAP DECODING FOR PERPENDICULAR MAGNETIC RECORDING WITH DATA DEPENDENT NOISE

M.Z. Ahmed[1], A. Fahrner[2] and P. Shah[1]

[1] *CRIST, University of Plymouth, PL4 8AA Devon, UK*

[2] *TAIT, University of Ulm, D-89081 Ulm, Germany*

Introduction : This paper presents the application of a new MAP algorithm to perpendicular recording in the presence of jitter noise. Respecting the limit on references, the following four references are provided as the fundamental basis for this work. For Maximum *A Posteriori* (MAP) decoding on trellis's[1] and previous work on jitter noise for longitudinal magnetic recording[2]. For the perpendicular channel model, we assume a hyperbolic tangent readback signal from an isolated transition $u(t)$, given by

$$u(t) = \tanh\left(\ln(3)\frac{t}{D_{50}}\right) \tag{1}$$

, where D_{50} is the normalised user density[3] and the target Partial Response given in [4].

We will present a modified trellis based algorithm that accounts for the differences between electronics and jitter noise in the metric computations. The fact that the jitter noise is greater in transitions compared to where there are no transitions can result in improved reliability of the metric computation. It has been found that this provides gains in performance over classical MAP algorithms that assume the noise is not data dependent.

Channel Model :

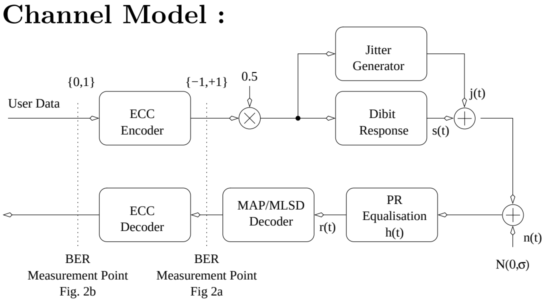

Fig. 1 : Simulation Block Diagram

The error correction code (ECC) is a (4096,3072) LDPC code. The received signal $r(t)$ can be described by the following equation

$$r(t) = h(t) * (s(t) + j(t) + n(t)) \tag{2}$$

where $h(t)$ is the impulse response of the PR equaliser, $s(t)$ is the channel readback waveform (with ISI), $j(t)$ is the transition jitter noise and $n(t)$ is AWGN, or the electronics noise and $*$ denotes convolution. We use noise prediction within the decoder, resulting in the Log–MAP decoded signal being described as

$$r(t) = h(t) * s(t) + j(t) + n(t) \tag{3}$$

Asymmetric Decoder (AD) : The AD includes 1 addition and 1 mul per branch metric computation in addition to the classic Log–MAP trellis decoder. Additionally, the decoder uses the input branch labels to determine if a particular path would include transition noise, so two consecutive state needs to be considered before the state metric is updated. This increases the computational complexity will be exponential as more terms around the transition are considered, and is seen as a limitation for higher D_{50}. The results compare fixed electronics SNR, and varying the maximum transition jitter within a sector of 4096 bits are shown for GPR[0.74,0.83,0.33,0.08,0.01] at $D_{50} = 1.0$.

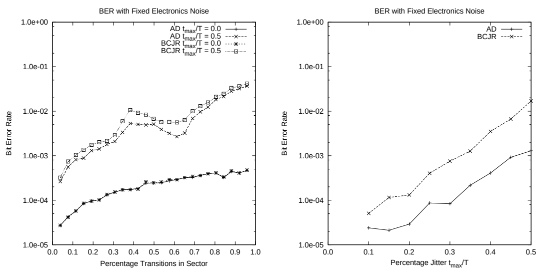

Fig. 2 : (a) BER vs. percentage of transitions, measured before ECC, and (b) BER vs. maximum jitter, measured after ECC.

The transition jitter is specified by t_{max}/T where t_{max} represents the maximum deviation in a bit period T. The variance of $n(t)$ for Fig 2a and Fig 2b are different, and were chosen for convenience.

Conclusion and Future Work : Results show a consistent improvement over BCJR with the use of ECC, however improvements are also dependant on the percentage of transitions, and show a maximum at 60%. Of interest is the fact that although the improvement in channel BER is not very much, the gain in decoded BER (Fig 2b) is 1 order of magnitude for large t_{max}/T. The jitter noise has been found not to be strictly Gaussian, due to the non–linear effect of ISI, and the future work will investigate on the use of more accurate probability density functions to decode it.

REFERENCES : [1]L. Bahl et al, *IEEE Trans Info*, 20, 284(1974). [2]W. Zeng et al, *IEEE Trans Magn*, 28(5), 2895(1992). [3]Y. Okamoto et al, *Tech Report IEICE*, MR2000–8, 1(2000). [4]W. Tan et al, *JMMM*, 287(2005), 397–404.